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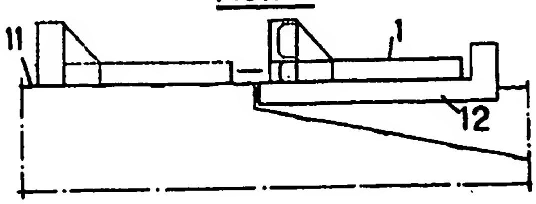
(54) **Offshore Gravity Platform Structures and Methods of Construction and Installation.**

(57) A method of constructing and installing an offshore reinforced concrete gravity platform structure 1 consisting of a caisson 6 integral with at least one column 5, in which the structure 1 is a) constructed on dry land on a substantially horizontal surface parallel to the axis of the column b) placed afloat in shallow water, maintaining the column axis horizontal c) uprighted in deep water d) towed to the site of installation and e) ballasted down to rest on the sea bed.

FIG.:1B



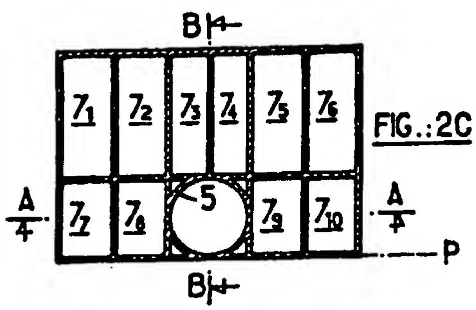


FIG.:2C

FIG.:2A FIG.:3

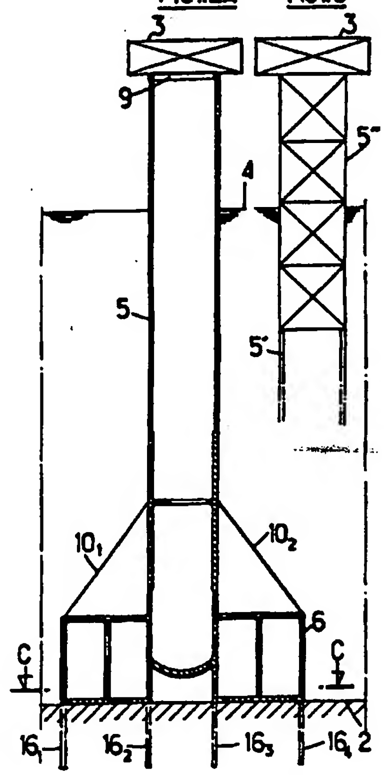


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FIG.: 1A

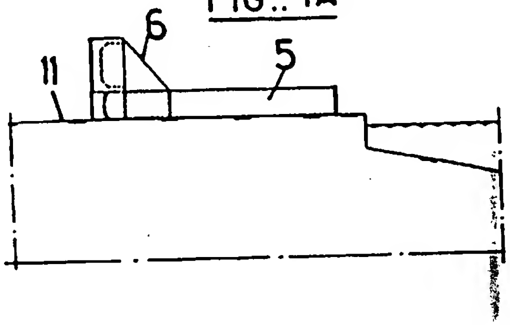


FIG.: 1B

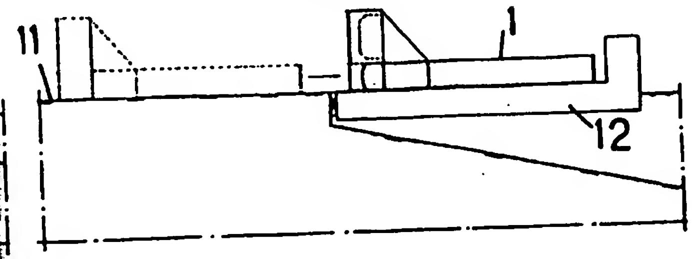


FIG.: 1C

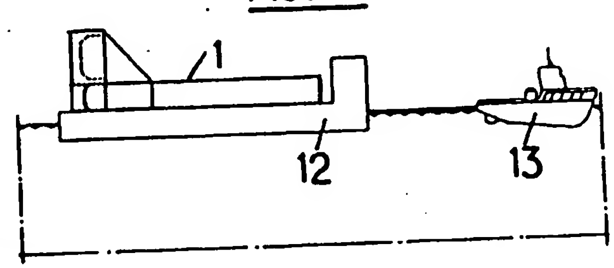


FIG.: 1D

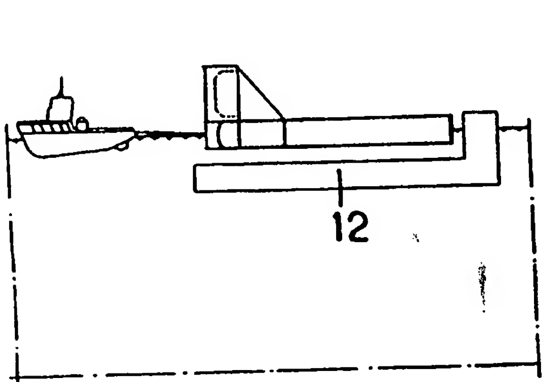


FIG.: 1E

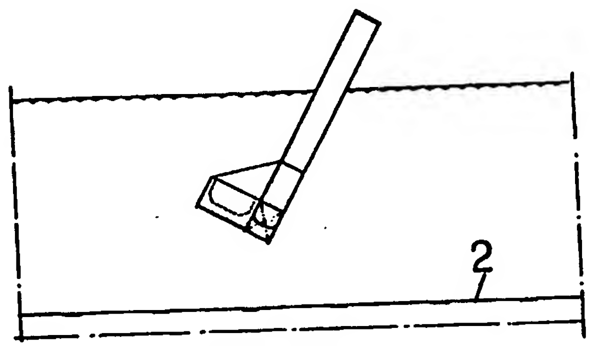


FIG.: 1F

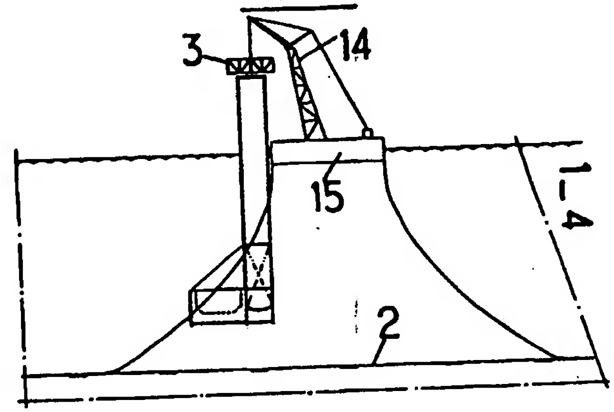


FIG.: 1G

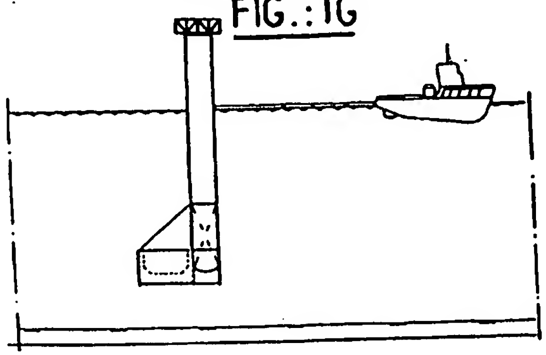


FIG.: 1H

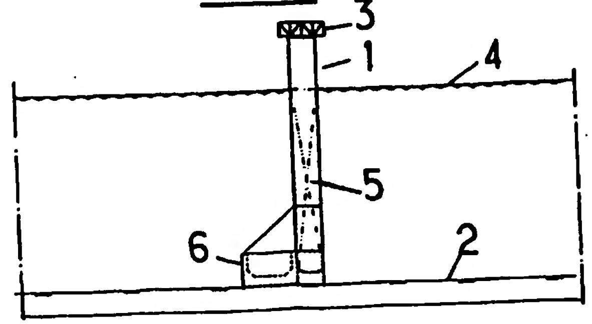
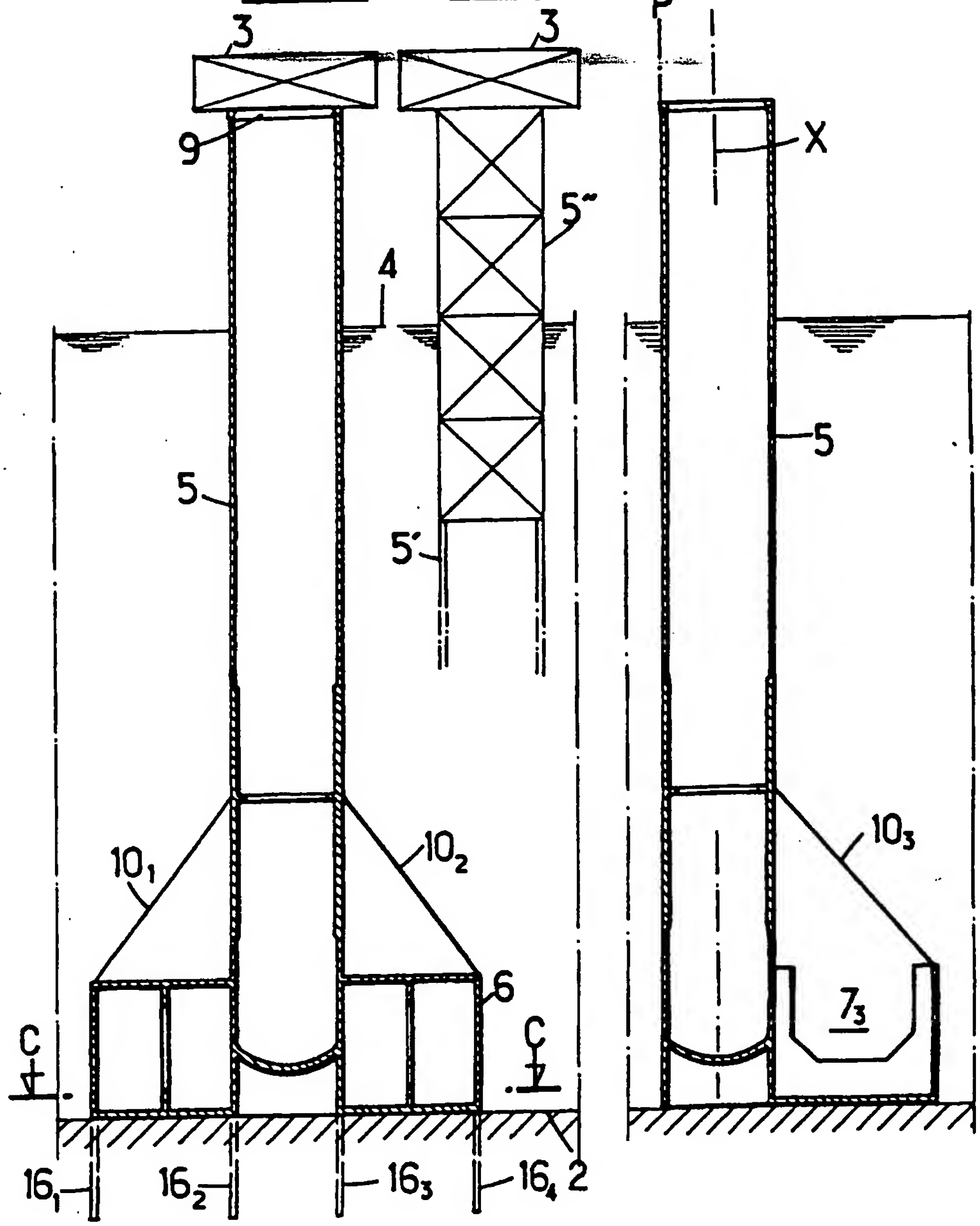


FIG.:2A FIG.:3 FIG.:2B



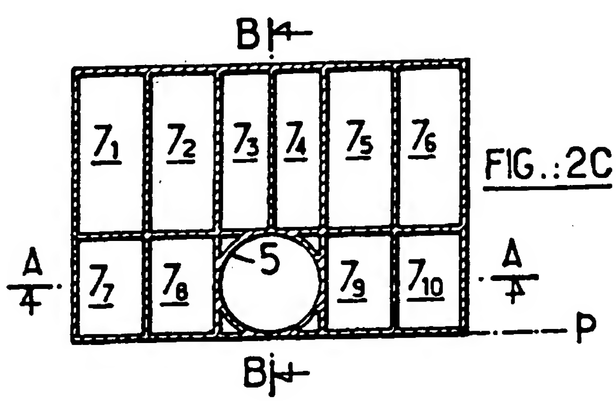


FIG.:2C

FIG.:4A

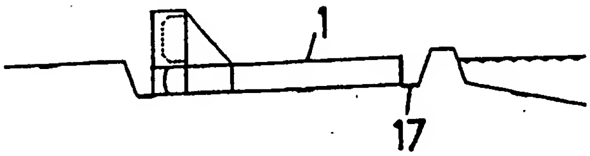


FIG.:4B

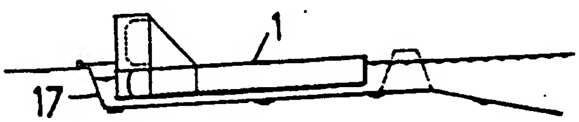


FIG.:4C

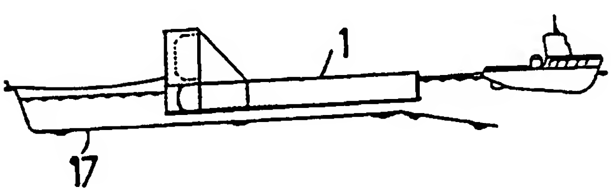


FIG.:5A

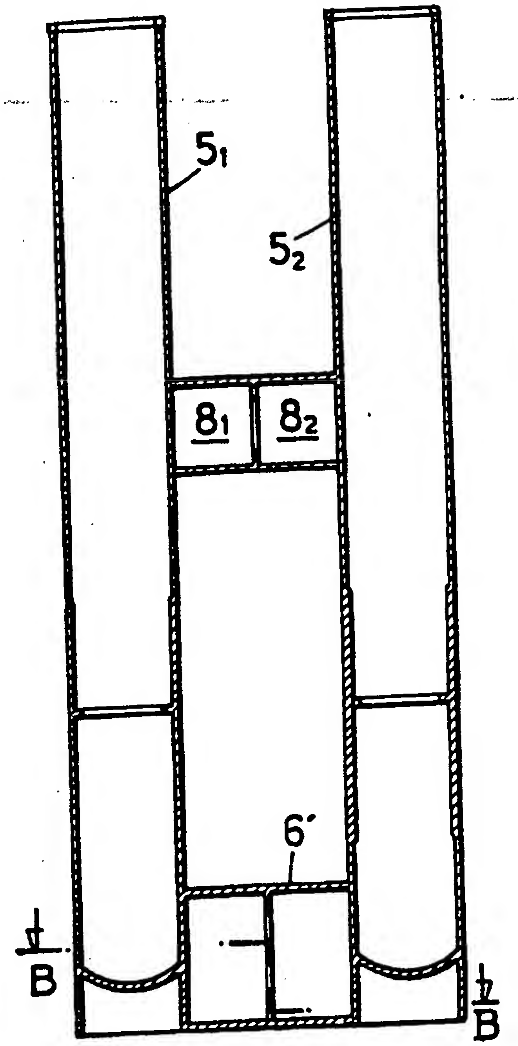
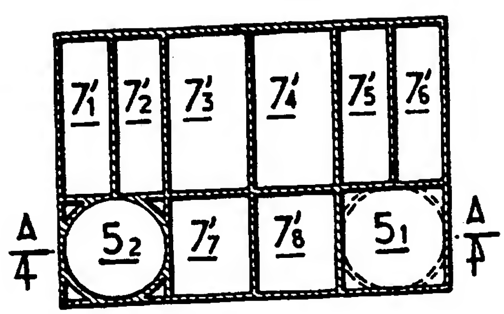


FIG.:5B



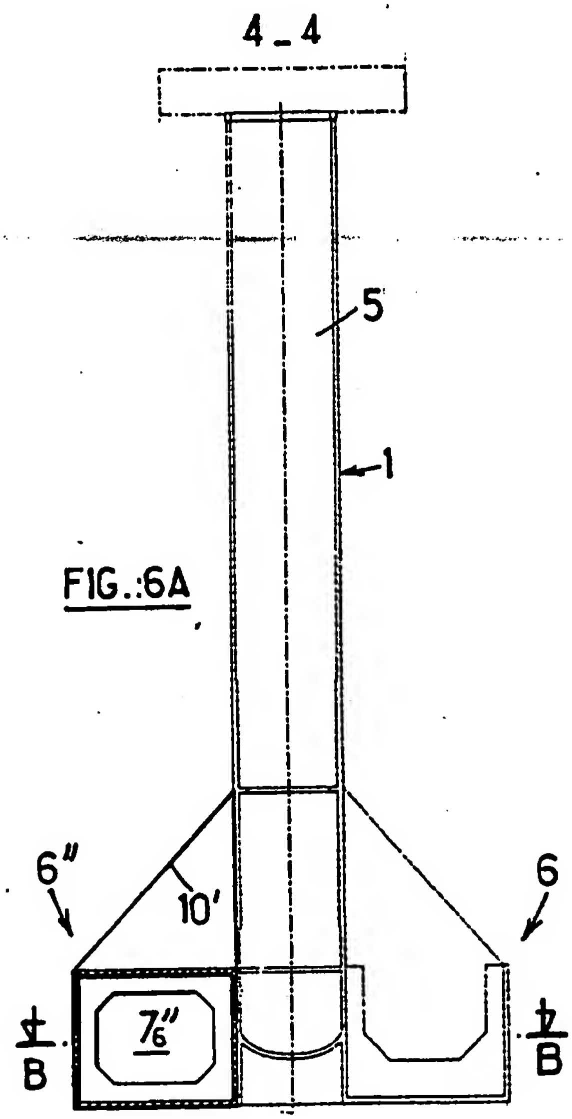


FIG.:6A

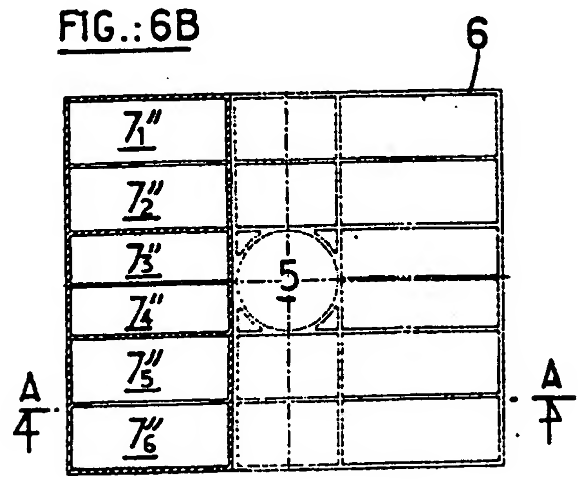


FIG.:6B

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Offshore Gravity Platform Structures and Methods of Construction and Installation

The present invention relates to a method for constructing and installing an offshore gravity platform structure, more particularly, a structure which consists of at least one column for supporting a deck and of a caisson which is integral with the column and is designed to rest on the seabed.

According to usual methods for constructing such a structure, the caisson of the structure is built in a dry dock, with its axis being oriented vertically, like in its final position on the site where it is to be installed. Once the caisson has been constructed, the dry dock is flooded and buoyancy means, installed internally or externally to the caisson ensure that the latter floats. The caisson is towed out of the dock by tugs to deep water, where the construction of the structure can continue. This allows the said structure to submerge progressively in the water as it becomes heavier, while continuing to float. Once construction is finished, the structure is equipped with a deck and it is towed to its final installation site. The caisson is then ballasted appropriately to lower it down onto the seabed so that it rests at its designated location. Final ballasting is carried out with seawater or solid materials to ensure the structure stability on the seabed.

Due to the shallow draught of the dry dock, this known method often leads to the caisson being oversized in order to satisfy the condition of its floatation at this stage of construction, in comparison to the dimensions which it could be designed for to fulfil its final function of providing a support for the deck and ensuring the stability of the structure in deep water. Furthermore, this method requires a well-sheltered deep-water site to be available close to the dry dock so that the construction of the structure can be completed.

This last constraint may be eliminated by constructing the structure, base and column, entirely in the vertical position, in a dry dock. However, the consequential oversizing of the caisson which is then required to enable the whole assembly to float in the condition of the shallow dry dock draught,

becomes prohibitive in terms of materials and labour cost.

Alternatively, to avoid the draught restriction, recourse may be to deepen the dry dock. However, this solution generally leads to excessive costs.

A structure for loading tankers at sea known as the "MAUREEN articulated loading column" was also constructed (see the British magazine OFFSHORE ENGINEER, pages 76-77, August 1982) using the method in which the elements of its column and of its base were assembled in a dry dock and the column was completed in horizontal position resting on the bottom of the dock. After the dock was flooded, the column and the base were towed separately out of the dry dock, the column floating horizontally, and then assembled together outside the dock with a cardan-type articulation. The column was then uprighted by ballasting it to come to a vertical position perpendicular to its base, this being made possible by the articulation. The structure was then fitted with a deck and its equipment, was towed to its final site and lowered down onto the seabed under gravity.

When a platform structure has to accommodate conductor tubes to allow the installation of surface wellheads, the structure described hereinabove cannot be envisaged because such conductor tubes would have to pass in the vicinity of the articulation, which would singularly complicate the construction. Furthermore, this concept is characterized by substantial torsional loadings at the articulation, during a phase of mounting the column horizontally with the base, and during the operational phase on the final site. The final point is that the assembly of the column and of the base in floating condition outside the dry dock is a complication of the construction method and makes it more expensive.

The object of the present invention is to provide an economical method for constructing and installing a gravity type offshore platform structure, eliminating the oversizing of the caisson of the said structure induced by the temporary construction phases, the need to have use of a well-sheltered deep-water construction site, and using a design which is not hampered by the drawbacks of articulated structures.

This object of the invention, as well as others which will become apparent from the description which follows, is achieved with a method for constructing and installing an offshore gravity platform structure made of reinforced or prestressed concrete, consisting of at least one column for supporting a deck and of a caisson integral with the column and designed to rest on a seabed, this method being notable in that the structure is constructed on dry land on a substantially horizontal surface parallel to the axis of the column under construction, the structure is then placed afloat in shallow water, keeping the said axis in a substantially horizontal position, the structure is uprighted in deep water so that the axis of the column comes to a substantially vertical position, the structure is then towed to the production site and ballasted down to rest on a seabed in the same vertical position.

The structure, as it will be demonstrated later, can float in shallow water without the need to oversize its caisson to limit the draught, as is the case when such a structure is constructed in the vertical position. Furthermore, as the concrete structure is entirely constructed on dry land, it is no longer necessary to provide a sheltered deep-water site to complete its construction. As the caisson is rigidly connected to the column, the structure is also free of the drawbacks of the articulated structure described hereinabove.

According to a first embodiment of the invention, the structure is constructed at the quayside, it is then loaded onto a ballastable barge, and it is placed in the water by releasing the barge from the structure, either by ballasting the barge or by launching similarly to a method used for steel structures.

According to another embodiment of the invention, the structure is constructed in a dry dock.

For the implementation of the method according to the invention, the invention describes a gravity platform structure, consisting of at least one support column, of a deck and of a caisson integral with the column, this structure being notable in that the column and the caisson are situated on one and the same side of a common tangential plane substantially parallel to the axis of the column.

By virtue of this geometry, it becomes possible to construct or to assemble the structure according to the invention on a horizontal surface coinciding substantially with the said tangential plane, on a quay or in a dry dock.

Other characteristics and advantages of the present invention will become apparent from the description below and from examining the appended drawing in which:

- Figures 1A to 1H diagrammatically illustrate a first implementation of the method according to the invention,
- Figures 2A to 2C are three sectional views of one embodiment of the platform structure according to the invention,
- Figure 3 represents a detail of an alternative implementation of the said structure,
- Figures 4A to 4C diagrammatically illustrate another implementation of the construction and installation method according to the invention,
- Figures 5A and 5B represent another embodiment of the structure according to the invention, and
- Figures 6A and 6B represent yet another embodiment of the structure according to the invention.

Reference is made to Figures 1A to 1H of the appended drawing, which diagrammatically illustrate the successive steps in the method according to the invention, with a purpose to installing a gravity platform structure 1 on a predetermined site of the seabed 2 (see Figure 1H), so that the top of the structure carries a deck 3 above the surface 4 of the water. The deck is able to support any kind of equipment for exploiting an offshore production oil field, such as wellheads, production equipment, living quarters, or tanker loading stations for example.

The structure 1 is represented in more detail in Figures 2A, 2B and 2C which are sections of this structure along section lines A, B and C respectively. In these views, it is clear that the structure, according to the embodiment represented, comprises an axisymmetric cylindrical column 5, connected to a caisson 6 designed to rest on the seabed 2 and forming a

monolithic assembly with the column. The caisson 6 comprises ballasting compartments 7_1 to 7_{10} capable of holding solid ballast materials such as sand, gravel, iron ore, etc. Some of these compartments may, as is well known, be closed and provided with sealing means so that they can be converted temporarily into buoyancy tanks for towing the structure to its final installation site.

The column 5 is hollow and it too may be closed off in order to form a buoyancy tank, before receiving water or other ballasting materials on the final site. Any conductors or risers which are provided within the structure are located preferably inside the column, thus being sheltered from wave action, and pass between the seabed and the deck 3 installed out of the water on the top 9 of the column, as will be explained later. Stiffeners 10_1, 10_2, 10_3,... stiffen the anchorage of the column 5 to the caisson 6.

The structure is designed to be made from reinforced and/or prestressed concrete. After ballasting it rests on the sea bed under its own weight.

According to one characteristic of the structure according to the invention, the column 5 and its caisson 6 are situated on one and the same side of a common tangential plane P (see Figure 2B) substantially parallel to the axis X of the column. The structure therefore has no axial symmetry which allows it to be manufactured by the method according to the invention, as explained hereinbelow in conjunction with Figures 1A to 1H.

According to a first implementation of the method according to the invention, the structure 1 is constructed or assembled on a quay 11 (see Figure 1A) exhibiting a substantially horizontal surface. This construction is therefore conveniently carried out from the plane P which is then substantially coincident with the surface of the quay, using conventional techniques known in the art of building offshore platforms in reinforced and/or prestressed concrete. The column may itself be produced by assembling lengths of column, which are cast vertically, then assembled horizontally.

The finished structure is then loaded onto a barge 12 (Figure 1B) moored alongside the quay 11 in shallow water. Such loading is possible for structures of medium dimensions, for example with an overall height of

120 metres and a total weight of approximately 15,000 tonnes (subsequently equipped with a deck of approximately 2000 tonnes) intended for marginal or satellite fields which may be developed only in an economical manner. In this respect, it should be noted that a conventional vertical construction of this structure in a dry dock would limit the height of the structure constructed on dry land to approximately 30 metres, so that this structure can be floated in shallow water close to the dry dock. It is then necessary to tow the part of the structure thus constructed to a sheltered deep-water site in order to finish the construction, which makes the costs excessive. The other conventional solution consists in greatly oversizing the caisson in order to decrease the draught of the part constructed in dry dock ; this solution is also very expensive in terms of materials and labour.

After the structure has been loaded onto the barge 12, a tug 13 tows the assembly to deep water (Figure 1C). After checking that the platform will float horizontally by guaranteeing the watertightness of the column or of part of the column and, possibly, of some compartments of the caisson which are used as buoyancy tanks, the barge is released from the structure by appropriate ballasting or any other launching means (Figure 1D). Flooding some of the ballasting compartments of the structure then makes it possible to tilt the latter up progressively (Figure 1E) to a substantially vertical position (Figure 1F). The platform is designed to float in this vertical position possibly with the aid of additional buoyancy means or counterweights (not represented) and the deck 3 is placed on the top of the column 9 using one or more loading cranes 14, carried for example by a pontoon 15. Structural connection between the deck 3 and the top of the column 9 is then carried out. The structure is then towed (Figure 1G) to the final site (Figure 1H). The platform is then slowly submerged down towards the seabed by appropriate control of the progressive flooding of the column 5. The caisson finally comes to rest on the bottom. The caisson may optionally, as represented in Figure 2A, be equipped with long skirts 16_1, 16_2 ... etc. intended to penetrate into a loose seabed to give the structure lateral stability, as described in French Patent FR-A-2,492,429. Appropriate ballasting of the compartments 7_i of the caisson with a solid ballast ensures the stability of the structure on the seabed.

This example shows a possibility to install a complete gravity platform structure together with a deck above the water, and ready for installation of intended equipment, at offshore deep water site, for example 100 or more metres deep. By virtue of the horizontal construction method according to the invention, which makes it possible to transport the complete structure through shallow water, an economical construction results from the fact that the structure can be constructed entirely "on dry land" and that the caisson 6 is dimensioned solely for its final function of acting as a foundation, and not in order to satisfy temporary condition of a heavy structure floatting at a shallow draught. The caisson may therefore have smaller dimensions, which is advantageous both in terms of materials and labour costs.

Figure 3 illustrates a part of an alternative implementation of the structure represented in Figure 2A. By virtue of this embodiment, the column is composed of a concrete lower part 5' which is entirely submerged at its final site, and of an upper metal lattice support 5" of a height capable of supporting the deck 3 above the water. This support may be assembled with the concrete part of column when horizontal, during construction on the quayside, or on site with the aid of floating cranes. Such a support greatly decreases the stress loadings on the structure which are due to the wave action.

Figures 4A to 4C represent a variation on the method illustrated in Figures 1A to 1H. Instead of constructing the structure on the quayside, the latter is constructed, still horizontally, in dry dock (Figure 4A). Once the construction is finished, the dock is flooded (Figure 4B) after it has been checked that the structure will float horizontally. The structure is then towed out of the dock (Figure 4C). The installation method then continues as illustrated in Figures 1E to 1H. Such a construction in dry dock provides a saving on the cost of the barge 12 used in the method illustrated in Figures 1A to 1H in case where the use of such a dry dock becomes more economical than the use of the barge.

In the foregoing, the deck is installed while the structure is floating in a vertical position. Alternatively, the deck may be installed once the structure has been put in place on the seabed under its own weight.

The column of the structure could be not cylindrical, but have a square or polygonal cross-section. It could also have a circular cross-section of variable diameter, so as to exhibit a truncated cone shape. The column cross-section will also comply with the operational conditions of use such as diameter or minimum internal dimensions, to allow enough clearance for receiving the conductor tubes for example.

Figures 5A and 5B represent sectional views of another embodiment of the structure according to the invention, along the section lines A and B respectively. The structure comprises two columns 5_1 and 5_2 integral with one and the same caisson 6' defining ballasting compartments $7'_1$ and $7'_8$. The strength of the structure may be enhanced by compartments 8_1 and 8_2 forming an intermediate brace for the columns. Such a two-column structure allows the installation, for example, of an elongated rectangular deck, or alternatively the use of columns for two different functions, such as drilling and the provision of utilities.

When circumstances dictate (for example increased depth or specific foundation conditions), the present invention also provides a solution to design structures with a symmetrical caisson shape, despite the asymmetry of the structures of Figures 2A, 2B and 5A, 5B. Figures 6A, 6B represent a platform structure according to the invention exhibiting this characteristic. In the elevation view of Figure 6A and in the plane view of Figure 6B it is clear that the structure comprises a structure 1 like that of Figures 2A, 2B, represented in dotted line, associated with a complementary caisson element 6" represented in solid line, consisting of ballasting compartments $7''_1$ to $7''_6$ and of stiffeners 10' symmetrical with the corresponding elements of the caisson 6 of the structure 1.

The complementary element 6" is made on dry land at the same time as the structure. It is placed in the water after it has been made buoyant by any known means or after having been fixed to floating support pontoons. It is assembled with the structure 1 while the latter is floating in the horizontal position. The complementary element is winched into the assembly position and this assembly is rendered permanent using prestressing cables. The assembly is then uprighted and installed on the site as illustrated in Figures 1E to 1H.

It is now clear that the present invention makes it possible to construct and to install gravity platform structures at sea in a particularly economical manner. Such structures are particularly, although not exclusively, intended for exploiting marginal or satellite hydrocarbon fields. They may also be associated with the concept of unmanned platforms.

CLAIMS

1. Method for constructing and installing an offshore gravity platform structure (1) made of reinforced concrete, consisting of at least one column (5; 5_1, 5_2) for supporting a deck and of a caisson (6; 6') integral with the column and designed to rest on a seabed, characterized in that:

- the structure (1) is constructed on dry land on a substantially horizontal surface parallel to the axis (X) of the column (5; 5_1, 5_2) under construction,
- the structure is then placed afloat in shallow water, keeping the said axis in a substantially horizontal position,
- the structure is uprighted in deep water so that the axis of the column comes to a substantially vertical position,
- the structure (1) is towed to the production side, and
- the structure is ballasted down to rest on a seabed (2) in the same vertical position.

2. Method in accordance with Claim 1, characterized in that, prior to towing the structure to the installation site, a deck (3) is installed on the column (5; 5_1, 5_2).

3. Method in accordance with Claim 1, characterized in that a deck (3) is installed on the column (5; 5_1, 5_2) after the structure (1) has been put in place on the seabed (2).

4. Method in accordance with any one of Claims 1 to 3, characterized in that the structure (1) is constructed on a quayside, the said structure is then loaded onto a ballastable barge (12), and the structure (1) is placed in the water (1) by releasing the barge (12) from the structure (1).

5. Method in accordance with any one of Claims 1 to 3, characterized in that the structure (1) is constructed in dry dock.

6. Method in accordance with any one of Claims 1 to 5, characterized in that a complementary element (6") of the caisson (6) is constructed on dry land and in that this element (6") is assembled with the caisson after the structure (1) and this element (6") have been placed afloat.

7. Method in accordance with any one of Claims 2 to 6, characterized in that the column is composed of a concrete lower part (5') which is entirely submerged on the final installation site, and of a metal lattice support

structure (5") which is mounted on the said concrete part (5') for supporting the deck (3) above the water.

8. Gravity platform structure designed for the implementation of the method in accordance with Claim 1, consisting of at least one support column (5; 5_1, 5_2), of a deck (3) and of a caisson (6; 6') integral with the column, characterized in that the column and the caisson are situated on one and the same side of a common tangential plane (P) substantially parallel to the axis (X) of the column.

9. Structure in accordance with Claim 8, characterized in that the caisson (6') supports at least two columns (5_1, 5_2).

10. Structure in accordance with either one of Claims 8 and 9, characterized in that the cross-section of the column varies along the axis (X) of this column.

11. Structure in accordance with either one of Claims 8 and 9, characterized in that the column is of cylindrical shape.

12. Structure in accordance with any one of Claims 8 to 10, characterized in that the column is of truncated cone shape.

13. Structure in accordance with any one of Claims 8 to 10, characterized in that the cross-section of the column is polygonal.

14. Structure in accordance with any one of Claims 8 to 13, characterized in that a complementary caisson element (6") is provided so as to be assembled with the caisson (6) constructed with the column, along the plane (P) tangential to the column and to the caisson.

15. Structure in accordance with any one of Claims 8 to 14, characterized in that the column is comprised of a concrete lower part (5') which is entirely submerged in its final position, and of an upper metal lattice support (5") which supports a deck (3) above the water.

16. Structure in accordance with any one of Claims 8 to 15, characterized in that the caisson (6) is equipped with long skirts (16) for anchoring it into the seabed (2).

17. Structure in accordance with any one of Claims 8 to 16, characterized in that at least one part thereof is made of prestressed reinforced concrete.

18. Method for constructing and installing an offshore gravity platform substantially as herein described with reference to figures 1A to 6B.

19. Gravity platform structure substantially as herein described with reference to figures 1A to 6B.

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Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report)	Application number GB 9521967.1
Relevant Technical Fields (i) UK Cl (Ed.N) E1H (HEA, HEB, HB, HCD, HEF) (ii) Int Cl (Ed.6) H02B 17/00, 17/02	Search Examiner A HABBIJAM Date of completion of Search 19 DECEMBER 1995
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE: WPI	Documents considered relevant following a search in respect of Claims :- 1-7, 18

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 1538759	(CANADIAN PATENTS AND DEVELOPMENT LTD) see in particular Figures 1, 4, 5 and 15-18	1, 2, 5
X	GB 1538758	(CANADIAN PATENTS AND DEVELOPMENT LTD) see in particular Figures 1, 4, 5 and 15-18	1, 2, 5
X	GB 1498047	(CANADIAN PATENTS AND DEVELOPMENT LTD) see in particular Figures 1, 4, 5 and 15-18	1, 2, 5

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